Digital Watermarking for Medical Diagnosis

Fawaz Alsaade and Md. Al-Amin Bhuiyan
mbhuiyan@kfu.edu
College of Computer Sciences & Information Technology, King Faisal University, Al Ahsa, Saudi Arabia.

Summary
Digital watermarking has attained a position of overwhelming interest in image processing research as a new method of protecting multimedia content from unauthorized copying, as the informal transmission and manipulation of digital data creates intimidation for inventors and providers. This paper presents a new watermarking system employing five bit LSB strategy for copyright protection of image contents. The method is based on converting the text information into binary data and representing each character by a length of five bit string and is organized with embedding information into the corresponding image files. The information is being extracted from the images by justifying the least significant bit of eight successive gray values and converting the bits into ASCII characters. The effectiveness of the method has been justified over CT scan, MRI and X-Ray images. Experimental results imply that the proposed algorithm performs better than the traditional LSB method.

Key words:
Digital watermarking, image, diagnosis, digital multimedia, protection, security, medical data, health care centers.

1. Introduction

A digital watermark is a slice of information which is implanted in the digital media in such a way that it is attached to its data. This slice of information known as watermark into multimedia object can be identified or pull out later to make a proclamation about the object. The healthcare center uses Electronics Patient Record (EPR) for aiding the sharing of patient information and exchange between networked hospitals and healthcare centers. For assurance of the safety, legitimacy and administration of medical images and information through storage and dissemination, the watermarking procedures are developing to defend the healthcare information. Digital watermarking facilitates in safe data transmission to defend data from illegal sources.

Recently many digital watermarking schemes have been proposed for copyright protection due to the rapid growth of multimedia data distribution. J. Nayak et al. proposed a technique for watermarking medical images with encrypted patient data in the spatial domain using error control codes [1]. M. Nambakhsh et al. presented a watermarking method combined with the embedded zero-tree wavelet algorithm (EZW) [2]. A. Giakoumaki et al. proposed a wavelet-based multiple watermarking schemes embedding four types of watermarks into the wavelet coefficients of medical images using a quantization of selected coefficients [3]. M. Kallel et al. developed an algorithm for embedding the patient's diagnosis in the spatial domain of medical image [4]. M. Barni et al. have developed a wavelet-based watermarking through pixel-wise masking according to characteristics of HVS color model [5]. The watermark is adaptively added to the largest detail bands. The watermark weighing function was calculated as a simple product of data extracted from HVS model. The watermark was detected by correlation. Victor et al. have developed an algorithm that relies upon adaptive image watermarking in high resolution sub-bands of DWT [6]. Weighting function is the product expression of data extracted from the HVS model. N. Kaewkamnerd and K.R. Rao developed a wavelet based image adaptive watermarking scheme [7]. Embedding was performed in the higher level sub-bands of wavelet transform, even though this can clearly change the image fidelity. In order to avoid perceptual degradation of image, the watermark insertion was carefully performed while using HVS. Bo Chen and Hang Shen developed a robust fragile double image watermarking algorithm using improved pixel-wise masking model and a new bit substitution based on pseudo-random sequence [8]. The method embedded robust and fragile watermark into the insensitive part and sensitive part of wavelet coefficients, making two watermarks non-interfering. Peng Liu and Zhizhong Ding proposed a blind image watermarking scheme based on wavelet tree quantization [9]. The largest two coefficients were selected as significant coefficients and the difference between them was taken as significant difference. A watermark bit was embedded by comparing the significant difference with an average significant difference value and maximum difference coefficients were quantized. Zhao Dawei et al. suggested a chaos-based robust wavelet domain watermarking algorithm [10]. They applied wavelet transform locally and embed watermark based on chaotic logistic map. N. Yassin et al. have proposed a comprehensive approach for digital video watermarking where a binary watermark image is embedded into the video frames [11]. Each video frame is decomposed into sub-images using two level discrete wavelet transform then the PCA transform is applied for each block in the two bands LL and HH. The watermark is embedded into the maximum coefficient of the PCA block of two bands. H. Luo et al. proposed a gray image digital watermarking

Manuscript received May 27, 2017
Manuscript revised July 20, 2017

algorithm combining discrete wavelet transform and discrete cosine transform with singular value decomposition based on chaos and scrambling in images [12].

This paper explores a method for embedding the EPR information in the medical image to save storage space, to guarantee security of patient information and to get ride from huge database management. The scheme is blind so that the EPR can be extracted from the medical image without the need of the original image. The rest of the paper is organized as follows. Section 2 describes LSB based digital watermarking, Section 3 outlines the experimental results. Section 4 analysis the performance of the method, and Section 5 draws the overall conclusions of the paper

2. LSB Based Digital Watermarking

In medical diagnostic centers, the information of patients are stored in separate database like, access, oracle, mysql etc. It needs enormous memory space to store text information and image separately. For this reason this research employs watermarking technique, in which text information is being kept in corresponding images. The system is based on least significant bit (LSB) method. The system architecture of the method employed for embedding watermark and extracting watermark of the proposed digital watermarking system are illustrated in **Fig. 1** and **Fig. 2**, respectively.

The traditional methods employed for digital watermarking [13-15] denote each character as an ASCII value. So eight bits are used to represent each character and it suffers from some problems. Firstly, these are not secured because no encryption techniques have been used during embedding information in images. Secondly, traditional LSB method is very sensitive to noise. To overcome these problems, this research proposes a new LSB method which is described below step by step.

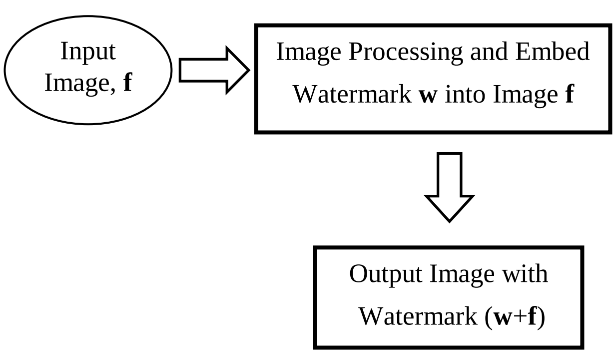


Fig. 1 Watermark embedding process.

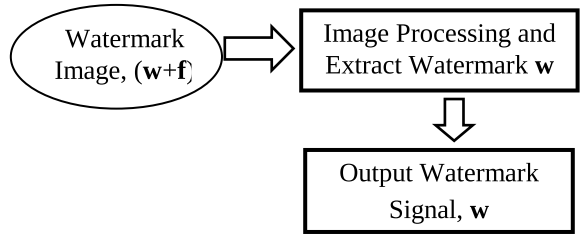


Fig. 2 Watermark extraction process.

In this proposed method only 5-bits will be used to represent one character. The character and corresponding value to be used in this method are given bellow.

- 0-25 is used for A-Z letters binary value (00000-11001)
- 0-9 reused for 0-9 digits binary value (00000-01001)
- 'space' represented by 26 binary value (11010)
- ':' represented by 27 binary value (11011)
- '/' represented by 28 binary value (11100)
- '-' represented by 29 binary value (11101)
- '.' represented by 30 binary value (11110)
- New line equal 31 binary value (11111)
- One pixel is to be used to represent one bit. So, five pixels need to represent one character.

The flow chart of the proposed LSB method to embed necessary information is shown in **Fig. 3**.

The proposed method follows some steps to embed desired information. The main steps for embedding information using proposed method are given bellow.

Step1

Convert the text information into binary data, **B**. Each character is represented by five bits.

Step2

Select a seed value (which will act as password) to generate a pseudo-random number. The pseudo-random number will be 0-4.

Step3

If the bit position of each character is equal to the pseudo-random number the logical NOT the bit.

Step4

Select the border pixel for embedding information. Top most three rows for name, mobile & age, bottom most three rows for name of the hospital or clinic, name of the doctor & diagnosis, left most two columns for gender & weight.

Step5

Insert binary data **B** into original image as watermark.

If the inserted bit is not equal to the least significant bit of $f(x_i,y_j)$ then-

If $f(x_i,y_j)$ is not equal 255, increase the gray value of $f(x_i,y_j)$ by 1.

Else decrease the gray value of $f(x_i,y_j)$ by 1.

Otherwise $f(x_i,y_j)$ will remain the same.

Step6

For each bit follow step5 three times.

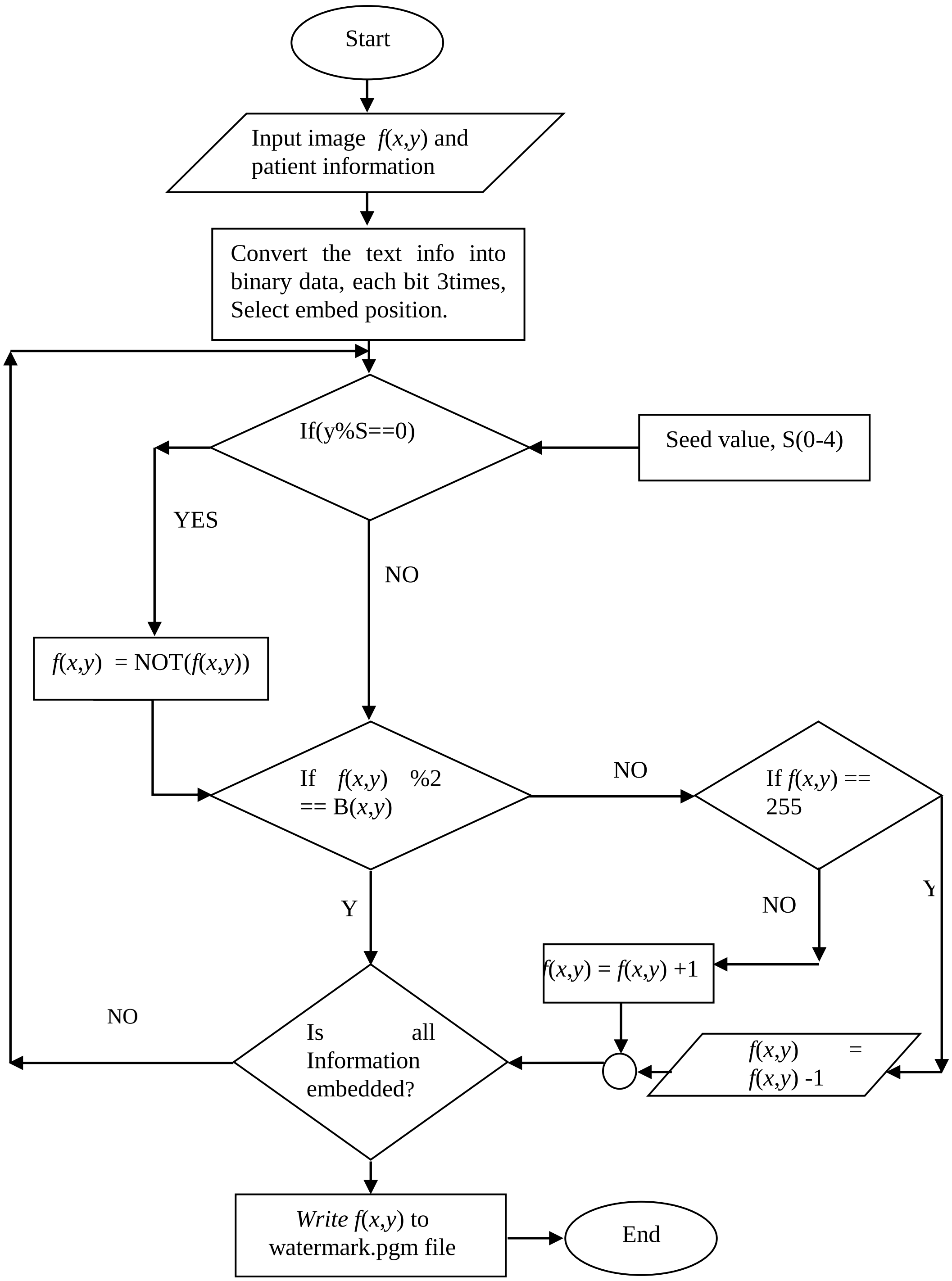


Fig. 3 Flowchart of the proposed method.

3. Experimental Results

The effectiveness of the proposed method has been justified over some experimental procedures. In order to embed the required information, the proposed LSB method was employed to the corresponding image, as shown in **Fig. 4**. To see whether the information is being embedded perfectly, the LSB method reads the least significant bit of five successive gray values and converts the bits to ASCII character. After extracting information from image shown in **Fig. 4**, the following information was obtained **(Fig. 5**).

Fig. 4 Sample medical image after embedding using proposed LSB.

Name: MD. MONIRUZZAMAN
Mobile Number: 01724528435
Age: 30 years
Gender: MALE
Weight: 64 kg
Blood Pr.: 120/80
Date: 04-01-2011
Clinic Name: POPULAR DIAGNOSTIC CENTRE
Dr. Name: DR. MOTAFIZUR RAHMAN
Diagnosis: BRAIN TUMOR

Fig. 5 Extracted information from image, shown in **Fig. 4**.

In order to measure the performance of the proposed LSB method over traditional LSB method, same sample image sets have been used and compared. Both the traditional method and the proposed method have been applied on three types of medical images, such as CT scan, MRI and X-Ray, of different sizes. The experimental results for CT scan, MRI and X-Ray image are shown in **Fig. 6**, **Fig. 7**, and **Fig. 8**, respectively.

3. Performance

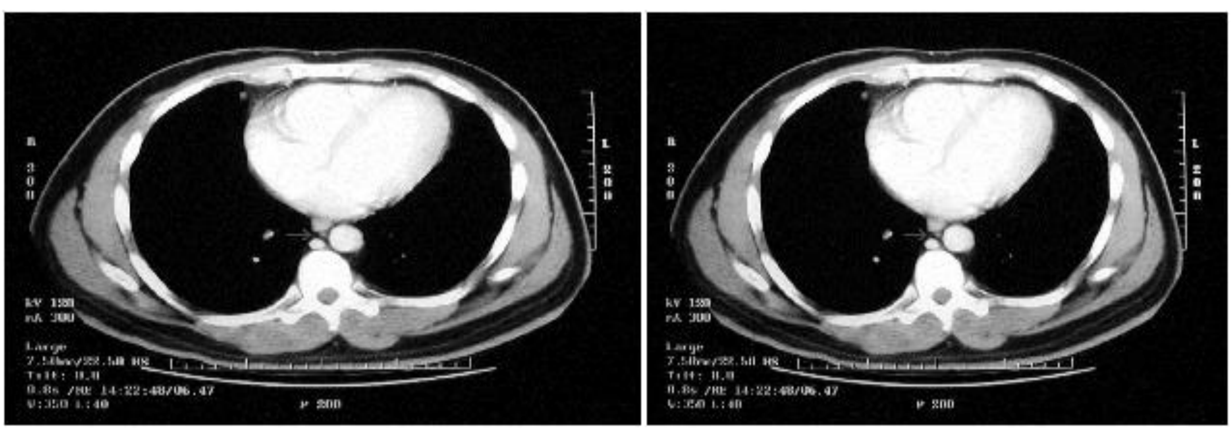
Both the traditional and the proposed methods can embed and extract information from image accurately if the image is not affected by noise. So in order to measure the performance of traditional and proposed LSB methods, experiments were carried out on noisy images. Computation of the accuracy was performed on the following equation:

$$Accuracy\ rate = \left(\frac{N_C}{T_W}\right) \times 100\% \qquad (1)$$

Where N_C is the Number of extracted correct words and T_W is the total words.

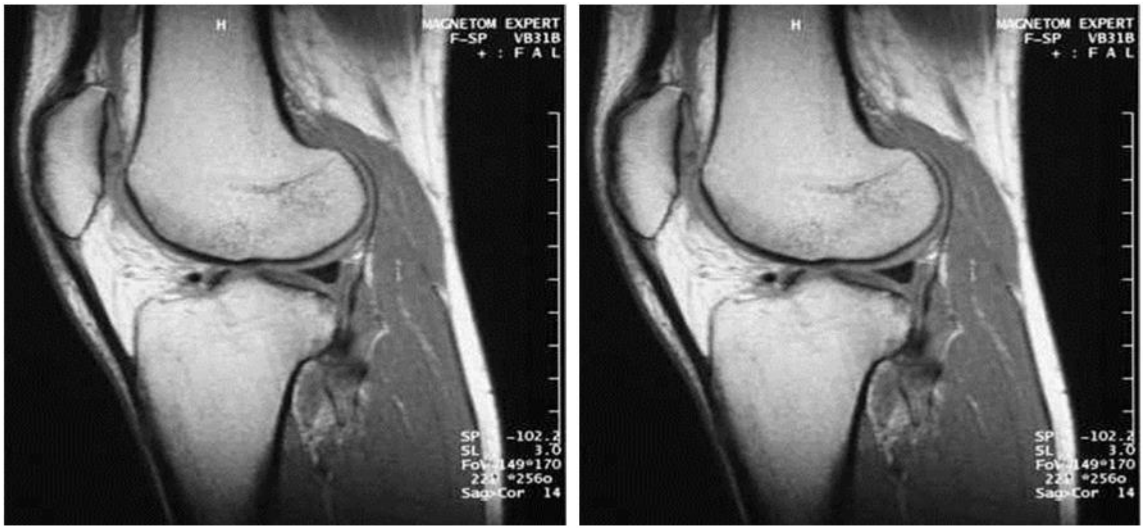
To add noise gray levels of 600 randomly selected pixels of the experimental images were changed. Before and after adding some noise in CT scan, MRI, X-Ray and Lena images the comparison of accuracy rate of both methods are shown in **Table 1**.

Table 1 reveals that information is being destroyed if the image is affected by noise in traditional LSB method. But the probability of destroying information in the proposed LSB method is less than traditional method. Because proposed method embeds each bit three times. If one bit is changed by affecting noise it can be recovered that from other two bits. The performance of the traditional method and the proposed method is shown in the bar chart. **Fig. 9** represents the bar chart of the traditional method and **Fig. 10** represents the bar chart of the proposed method, where x-axis represents number of words and y-axis represents images.



(a) Traditional LSB method (b) Proposed LSB method

Fig. 6 Brain tumor CT scan image (928×728) after embedding EPR.



(a) traditional LSB method (b) proposed LSB method

Fig. 7 Knee MRI image (350×381) after embedding EPR.

(a) traditional LSB method (b) proposed LSB method

Fig. 8 Finger X-ray image (560×390) after embedding EPR.

Table 1: Performance Comparison between Traditional and Proposed LSB Methods

Image	Image Size	Accuracy rate before adding noise		Accuracy rate after adding noise	
		Traditional LSB Method	Proposed LSB Method	Traditional LSB Method	Proposed LSB Method
CT scan	928×728	100%	100%	12.5%	100%
MRI	350×381	100%	100%	15.38%	100%
X-Ray	560×390	100%	100%	35.71%	100%
Lena	500×500	100%	100%	50%	94.44%

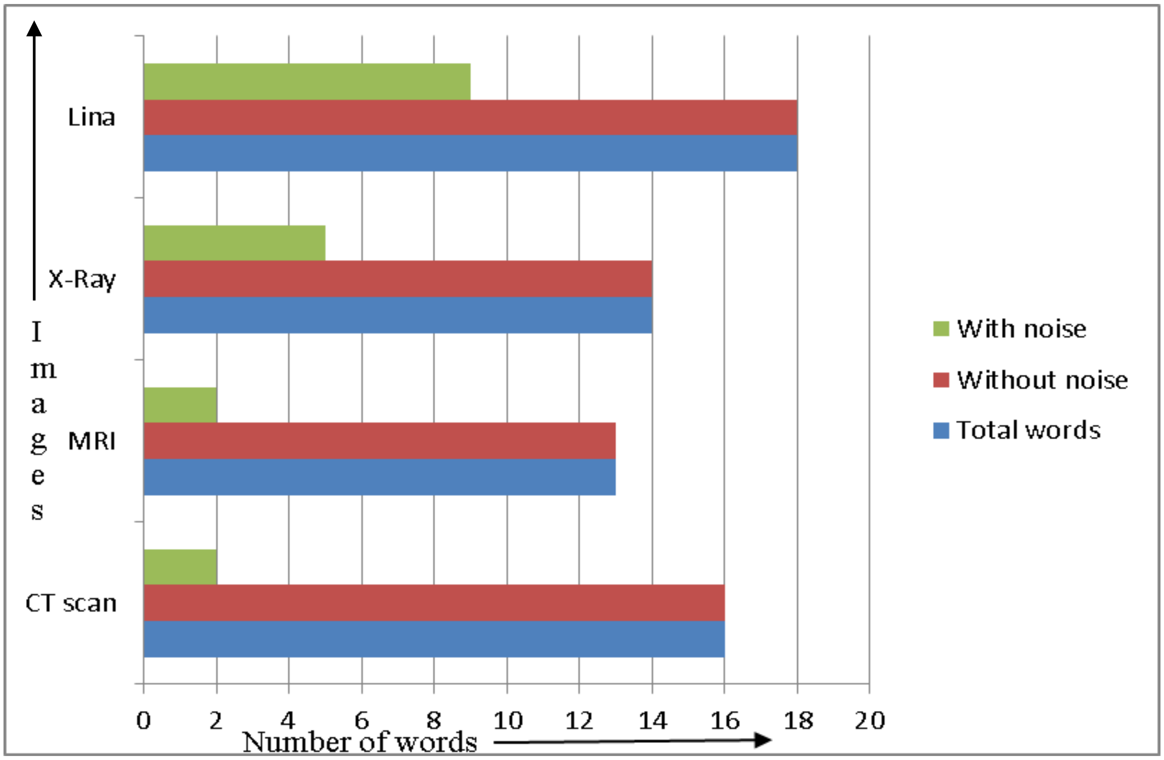


Fig. 9 Performance analysis of the traditional method.

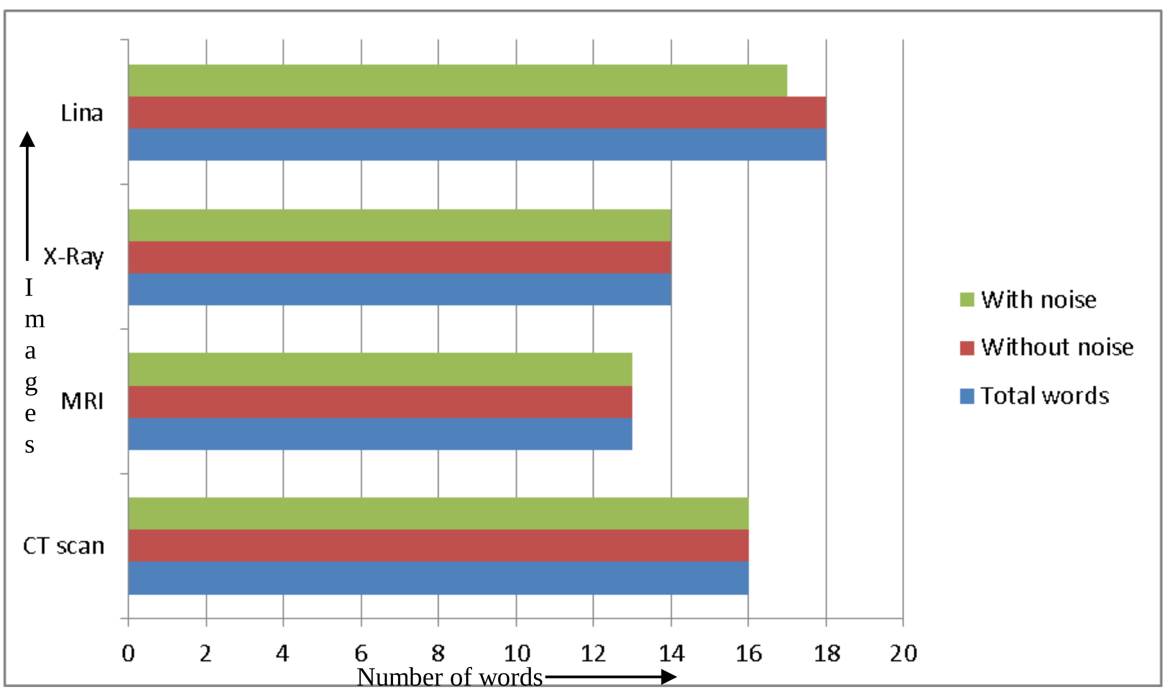


Fig. 10 Performance analysis of the proposed LSB method.

5. Conclusions

This paper proposes a new digital watermarking method using least significant bit (LSB) scheme. Experimental results indicate that the proposed watermarking system performs strong robustness against noise addition. Although there is no visual difference after embedding watermark using both traditional and the proposed methods, the proposed LSB method is nevertheless better than the traditional LSB method with three folds considerations: (i) the proposed method is less affected by noise, (ii) the proposed LSB method is more secured because it is password protected, and (iii) the proposed method uses 5-bits to represent one character whereas traditional method needs 8-bit to present one character. In this context, this research will explore a technique for embedding the EPR information in the medical image to save storage space and to guarantee security and to get ride from huge database. The scheme is blind so that the EPR can be extracted from the medical image without the need of the original image. Therefore, this proposed technique is useful in telemedicine applications. Using this method any text information can be transferred with high security because of its password protection.

Acknowledgements

The authors express their gratitude to the Deanship of Scientific Research, King Faisal University, Hofuf, Al-Ahsa, Saudi Arabia for funding this research under Project No. 150181.

References

[1] J. Nayak, P.S. Bhat, M.S. Kumar, and R. Acharya, "Reliable transmission and storage of medical images with patient information using error control codes", In: Proc. IEEE INDICON, pp.147-150, 2004.

[2] M. Nambakhsh, A. Ahmadian, M. Ghavami, R. S. Dilmaghani, and S. Karimi-Fard, "A Novel Blind Watermarking of ECG Signals on Medical Images using EZW Algorithm", 28th Annual International Conference of the IEEE Engineering in Medicine and Biology Society, pp. 3274-3277, 2006.

[3] A. Giakoumaki, S. Pavlopoulos, and D. Koutsouris, "Multiple image watermarking applied to health information management", IEEE Trans. Inf. Technol. Biomed., vol. 10, no. 4, pp. 722-732, 2006.

[4] M. Kallel, J. Lapayre, and M.S. Bouhlel, "A multiple watermarking scheme for medical image in the spatial domain", GVIP J., vol. 7, no. 1, pp. 37-42, 2007.

[5] M. Barni, F. Bartolini, and Piva, "An Improved Wavelet Based Watermarking Through Pixelwise Masking", IEEE transactions on image processing, Vol. 10, pp.783-791, 2001.

[6] V. Victor and M. Guzman, "Analysis of a Wavelet -based Watermarking Algorithm", IEEE Proceedings of the International Conference on Electronics, Communications and Computer, pp. 283-287, 2004.

[7] N. Kaewkamnerd and K.R. Rao, "Wavelet Based Image Adaptive Watermarking Scheme", IEEE Electronic Letters, Vol. 36, pp.312-313, 2006.

[8] Bo Chen, Hong Shen, "A New Robust -Fragile Double Image Watermarking Algorithm", Third IEEE International Conference on Multimedia and Ubiquitous Engineering, pp. 153-157, 2009.

[9] P. Liu and D. Zhizhong, "A Blind Image Watermarking Scheme Based on Wavelet tree Quantization", Second IEEE International Symposium on Electronic Commerce and Security, pp. 218-222, 2009.

[10] D. Zhao, C. Guanrong, and L. Wenbo, "A Chaos-based Robust Wavelet-domain Watermarking Algorithm", IEEE International Conference on Multimedia and Expo (ICME), 2010.

[11] N. Yassin, N. Salem, and M. Adawy, "Block Based Video Watermarking Scheme using Wavelet Transform and Principle Component Analysis", IJCSI International Journal of Computer Science Issues, Vol. 9, No. 1, 2012.

[12] H. Luo, S. Long, and C. Jiang, "A Kind of Research on Gray Image Watermarking Algorithm based on Chaos", Proceedings of International conference on Information Technology and Management Science (ICITMS), Springer-Verlag, Berlin Heidelberg, pp. 731-740, 2013.

[13] P.K. Dhar, M.I. Khan, and K. Jong-Myon, "A New Audio Watermarking System using Discrete Fourier Transform for Copyright Protection", IJCSNS International Journal of Computer Science and Network Security, VOL.10 No.6, June 2010, pp. 35-40.

[14] A. Bamatraf, R. Ibrahim and M. Najib, "A New Digital Watermarking Algorithm Using Combination of Least Significant Bit (LSB) and Inverse Bit", Journal of Computing, Vol. 3, No. 4, 2011, pp. 1-8.

[15] D. Chopra, P. Gupta, G. Sanjay, A. Gupta, "LSB Based Digital Image Watermarking For Gray Scale Image", IOSR Journal of Computer Engineering (IOSRJCE), Vol. 6, No. 1, pp. 36-41.

Dr. Fawaz Alsaade received the Bachelor and Master degree in Computer Science from King Abdulaziz University, KSA, in 1998 and Western Michigan University, USA, in 2003, respectively. He got his PhD degree in Artificial Intelligence, University of Hertfordshire, UK, in 2008. Currently Dr. Fawaz is an Associate professor at the Computer Science Department, College of Computer Science and Information Technology, Saudi Arabia. His research interests include artificial intelligence, image processing, biometrics, pattern recognition, and so on. He has published numerous articles in international refereed journals and conference proceedings.

Dr. Md. Al-Amin Bhuiyan received both his Bachelor and Master degree from University of Dhaka, Bangladesh, in 1987 and 1988, respectively. He got his PhD degree from Osaka City University, Japan in 2001. Currently he is a an Associate Professor at the Department of Computer Engineering, College of Computer Science and Information Technology, King Faisal University, Saudi Arabia (under lien leave from Jahangirnagar University, Bangladesh where is employed as a Professor). Prior to this, Dr. Bhuiyan lent his teaching and research experiences at several Universities in Japan, Bangladesh and UK. His research interests include image processing, computer graphics, pattern recognition, artificial intelligence, neural networks, robotic vision, and so on.